Check List **3**(4): 321–329, 2007.
ISSN: 1809-127X

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Fish, Sternoptychidae, *Maurolicus stehmanni* Parin & Kobyliansky, 1993: Occurrence and distribution in south and southeastern Brazilian waters.

Eduardo M. Almeida [1]
Carmen Lúcia D. B. Rossi-Wongtschowski [2]

[1] *Centro de Pesquisa e Gestão de Recursos Pesqueiros do Nordeste — Cepene, Instituto Chico Mendes de Conservação da Biodversidade — ICMBio. Rua Samuel Hardman s/n. CEP 55578-000. Tamandaré, PE, Brazil.*

[2] *Instituto Oceanográfico da Universidade de São Paulo — IOUSP. Praça do Oceanográfico 191, sala 103A. Cidade Universitária, Butantã. CEP 05508-120. São Paulo, SP, Brazil. E-mail:* cwongski@usp.br

The genus *Maurolicus* is composed by mesopelagic fishes widespread in temperate, subtropical and tropical areas being more abundant on continental slopes. The species of *Maurolicus* are an important component of the food chain in deep waters, preying on zooplankton and being the most common prey for large predators, such as tuna and squids (Boehlert et al. 1994; Rasmussen and Giske 1994; Parin and Kobyliansky 1996; Muto et al. 2005). Its importance for the diet of fish with commercial value in Brazilian waters was noted by Zavala-Camin (1981), Haimovici et al. (1994), Ribeiro (1996), and recently by Muto et al. (2005) and Gasalla et al. (2007).

Regarding the possibility of its commercial exploitation, Gjøsæter and Kamaguchi (1980) suggested that mesopelagic fish stocks would be looked as potential resources due to depletion of most of the conventional fish stocks, as they have high production values in tropical and subtropical waters. However, Salvanes and Stockley (1996) warn that, this exploitation would be carried carefully, taking in account their importance in the food web of deep waters. On the other side as these species normally present high abundance and short life cycles; they are important indicators of changes in the ecosystem, being very opportune to know about its taxonomic position, growth and reproductive parameters.

Grey (1964), analyzing the number of photophores of *Maurolicus* species collected around the world found no regional differences, except in the numbers of gillrakers, concluding that it was a monotypic genus. Later, Parin and Kobyliansky (1993; 1996) recognized fifteen allopatric species and, based on meristic and morphological characteristics and distribution, proposed an identification key for the genus. In support to the idea of a polytypic genus, Suneetha et al. (2000) confirmed genetic differences between *M. muelleri* (North Sea) and *M. walvisensis* (South Africa), agreeing with the slight morphological differences proposed by Parin and Kobyliansky (1993; 1996) differentiating these two species.

The studies on *Maurolicus* in Brazilian waters have always referred to the species as *Maurolicus muelleri* (Zavala-Camin 1981; Weiss et al. 1988; Bonecker and Hubold 1990; Haimovici et al. 1994; Ribeiro 1996; Greig 2000), although the revision of the genus by Parin and Kobyliansky (1993; 1996) distinguishes a new species in the Southwest Atlantic (between 34° and 40° S), named *Maurolicus stehmanni*.

Taking in consideration that 1- for the diagnoses of these two species Parin and Kobyliansky (1993; 1996) did not used material from the area under investigation (22° - 34° S), but only from the adjacent and southern ones (34° and 40° S), and 2- a considerable overlapping of meristic and morphometric characteristics occurs between *Maurolicus muelleri* and *Maurolicus stehmanni*, the objective of the present study was to identify the species inhabiting the South-Southeast Brazilian EEZ between 22° and 34° S.

The area in which the studied specimens were collected is located between Cabo de São Tomé (22° S) and Arroio Chuí (34° S) along the outer continental shelf, the shelf break and the upper slope, between depths from 100 to 1500 meters (Figure 1).

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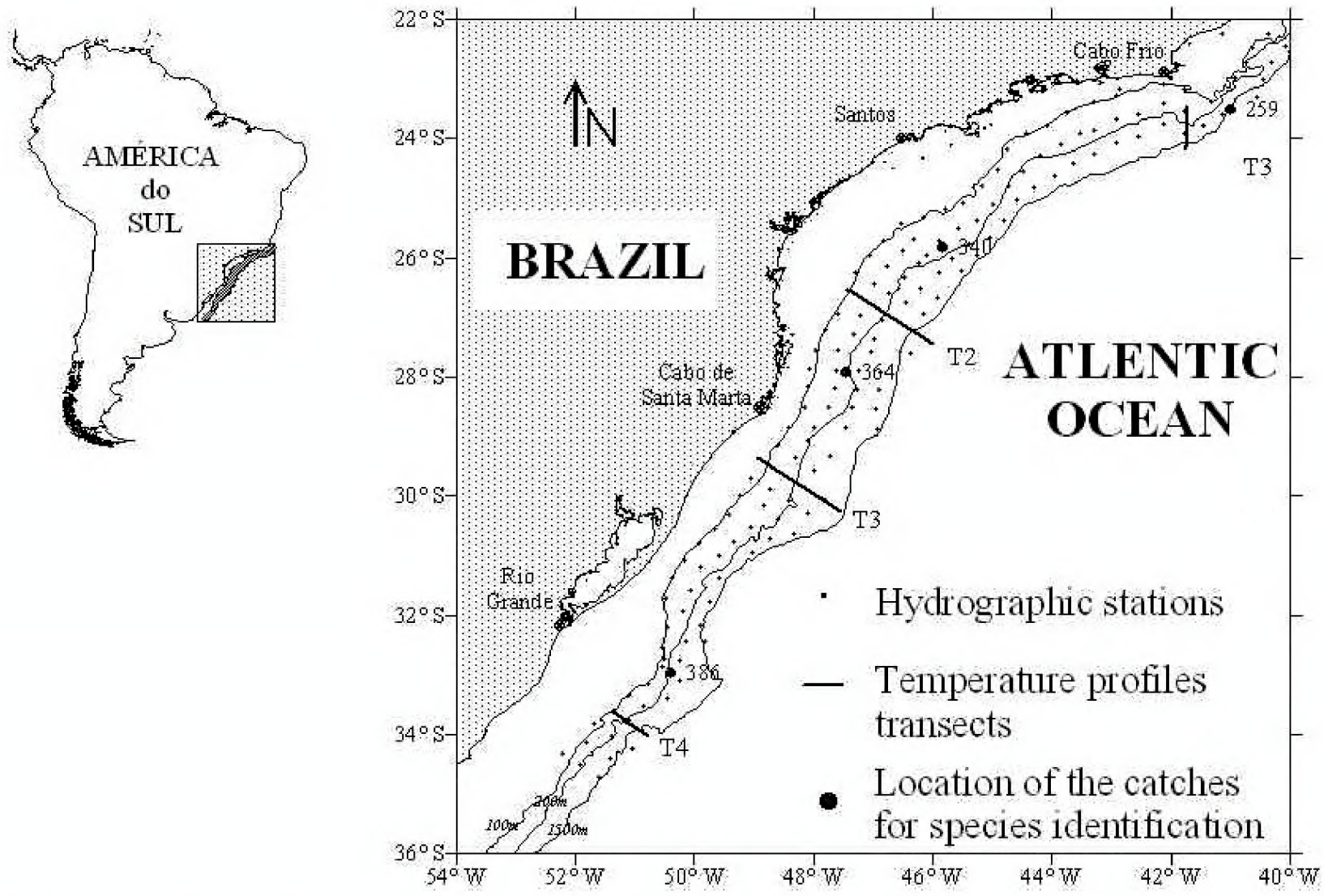

Figure 1. Surveyed region: The smaller dots indicate the oceanographic stations, the bigger circles show the positions of the catches used for species identification. The lines (T1 – T4) show the position of representative temperature transects along the area.

Figueiredo et al. (2002) presented a synthesis of the prevailing oceanographic conditions of the area, but it is important to emphasize that it is influenced by the large scale superficial circulation, dominated by the Brazilian Current (BC) and the Subtropical Convergence (STC). The BC flows southward along the Continental Slope until it meets the Malvinas Current (MC), which flows northwards, thus limiting the STC, a narrow thermal front. The position of the STC depends on climatic conditions and moves between 35^0 and 45^oS (Seeliger et al. 1997; Campos et al. 2000).

Fish were collected along the Atlantic Brazilian EEZ during three hydroacoustic surveys undertaken by the R.V. *Atlântico Sul* in the winter of 1996, the autumn of 1997, and the spring of 1997. The sound scattering layer (SSL) was monitored continuously by an echo sound and in order to identify the faunistic composition of the schools detected a mid-water trawl was used. This trawl was specially designed for the R. V. *Atlântico Sul* to provide the capture of small pelagic fish and squids; it had an opening of 269 m^2 and the stretched mesh size of the net decreased gradually from 400 mm to 50 mm. The stretched mesh size of the cod end was 20 mm and in the second and third cruises a cover net with smaller mash was added to the fishing gear.

The fish caught in each haul were identified to species (or genus), being a sample of *Maurolicus* frozen in order to be analyzed. Temperature and salinity profiles were obtained with a CTD sounder every 36 km along the route and the vertical distribution of temperature and salinity of some transects were analyzed. In order to compare our results with those of Parin and Kobyliansky (1993; 1996) their methodology about morphometric and meristic characteristics was adopted. Fishes collected from representative catches from the north, centre and south part of the area were examined. Males and females were treated separately and their morphometric and meristic characters were compared by T-tests.

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Morphometric analysis

The following measurements were recorded to the nearest 0.1 mm: standard length - SL (distance from the snout to the caudal peduncle); head length – HL (distance from snout to the posterior edge of the operculum); eye orbit diameter – ED; and maximum body depth – BD (vertical distance, perpendicular to the longitudinal axis between the dorsal and the ventral edges of the body near the insertion of the pectoral fin). HL, BD and ED data were plotted against SL in order to verify ontogenetic changes and body proportions were calculated as percentages of HL, ED and BD in relation to SL.

Meristic analysis

The pectoral, dorsal, caudal and ventral fin ray number; the number of gill rakers in the first arch; the number of vertebrae; and the number of caudal photophores was counted.

The nonparametric Kruskal-Wallis and Dunn's Multiple Comparison tests were applied to analyse possible statistical differences in meristic counts and body proportion measurements among the samples.

Since *Maurolicus* is considered a pseudo-oceanic genus, *i.e.* it is associated with continental slopes (Grey 1964; Gjøsæter 1981; Clarke 1982; Rasmunssen and Giske 1994; Goodson et al. 1995; Salvanes and Stockley 1996), the results obtained were compared with those used for the diagnoses of *Maurolicus* species distributed in adjacent areas (according to Parin and Kobyliansky 1996) and also with those of *M. muelleri*, since the later is the name that had been attributed to the species along the southern Brazilian coast.

Species identification

Specimen's collection sites and catch data are given in Table 1. Fish lengths ranged from 25 to 47 mm. The HL, BD and ED data plots in relation to SL detected no changes during development (Figure 2). Morphological and meristic data are given in Tables 2 and 3. The T-test demonstrated the similarity between males and females for all characteristics (P values < 0.0001).

Table 1. Location and catch data.

Trawl number	Position		Date	Time
	Latitud	Longitud		
259	41°01' S	23°31' W	24 May 97	16:45
340	45°50' S	25°49' W	28 Nov 97	19:50
364	47°27' S	28°11' W	07 Dec 97	19:50
389	50°24' S	32°58' W	20 Dec 97	01:15

The Kruskal-Wallis test rejected the hypothesis of homogeneity among the samples for meristic data and DB/SL, HL/SL and ED/SL body proportions. Dunn's Multiple Comparison test revealed: 1) fish from station 386 (south area) had a significantly higher proportion of eye to body (ED/SL) ratio than those from the northern stations; and 2) fish from stations 386 and 364 (central area) had a significantly higher proportion of head length to body length (HL/SL) ratio than specimens from the northern stations (Table 4). However these differences were not large enough to suggest that more than one species inhabits the surveyed area, being the obtained values in the range of those presented by Parin and Kobyliansky (1996) for *M stehmanni*. Nevertheless, in order to define which species is present in the Brazilian ZEE, the key of these authors was not appropriate for a clear separation between *M. stehmanni* and *M. parvipinnis* (Table 5), since most of the data overlapped. So, for a final diagnose we used Parin and Kobyliansky's (1996) statement that "the species of the genus *Maurolicus* are allopatric" and so, since *M. stehmanni* occurs in the Western South Atlantic and *M. parvipinnis* in the Eastern South Pacific (Parin and Kobyliansky 1993; 1996) we concluded that, in the south and southeast Brazilian EEZ, between 22° and 34° S, we have the occurrence of *Maurolicus stehmanni*.

Oceanographic conditions

In general, during the cruises, the water column at the oceanic stations was homogeneous down to 100 meters, declining thereafter, indicating the beginning of a permanent thermocline (Figure 3).

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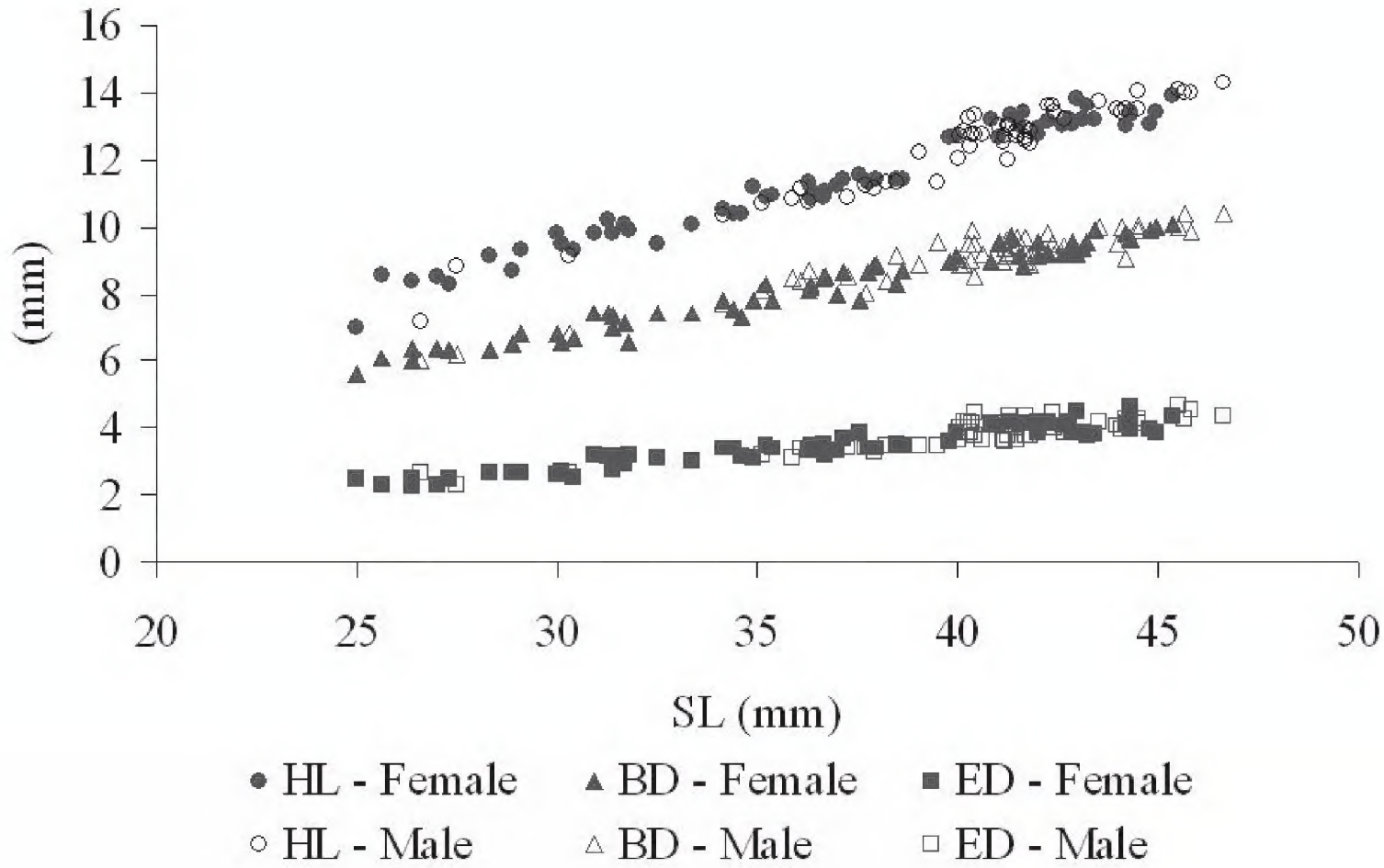

Figure 2. *Maurolicus stehmanni*: Head lengths (HL), body depth (BD) and eye orbit (ED) plotted against standard length.

Table 2. Mean values and confidence intervals (□ = 0.05) of the body proportions of the head length (HL), the body depth (BD) and the eye orbit diameter (ED) against standard length (LS) of *Maurolicus* caught in four distinct locations (trawl number)

Trawl number	Sample Size	HL/SL (%)		BD/SL (%)		ED/SL (%)	
		Mean	C.I.	Mean	C.I.	Mean	C.I.
259	30	30.6	0.3	22.4	0.2	9.1	0.1
340	30	30.2	0.2	22.7	0.3	9.4	0.2
364	30	31.1	0.5	22.6	0.3	9.2	0.2
386	30	31.5	0.3	22.3	0.3	10.0	0.1
Total	120	30.8	0.2	22.5	0.1	9.4	0.1

Table 3. AC – phothophores, rays of dorsal fin, rays of the pectoral fin, gill rakers and vertebrae counts from *Maurolicus* captured in four distinct locations (trawl number).

Trawl number	Number of AC-Photophores					Number of rays of the dorsal fin				Number of rays of the pectoral fin					Number of gill rakers						Number of vertebrae	
	24	25	26	27	28	10	11	12	13	15	16	17	18	19	25	26	27	28	29	30	33	34
259	3	14	11	2		4	25	1		1	4	17	7	1	4	6	16	3	1		12	16
340	5	13	9	2	1	3	21	5		1	2	12	15		3	9	9	8	1		10	19
364	3	18	9				15	15			2	17	11			12	13	5			8	17
386	4	15	11			4	15	5	6		3	17	7	3		7	13	7	2	1	12	17
Total	15	60	40	4	1	11	76	26	6	2	11	63	40	4	7	34	51	23	4	1	42	69

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Table 4. *Maurolicus stehmanni*: A - Summary results for homogeneity according to the Kruskal Wallis test for meristic and morphometric data (ED - eye diameter; HL - head length; BD - body depth; and SL - standard length). B - Dunn´s multiple comparison test results for ED/SL and HL/SL.

A

HL/SL	P<0.0001
DB/SL	P=0.067
ED/SL	P<0.0001
AC Photophores	P<0.7769
Rays of dorsal fin	P<0.061
Rays of pectoral fin	P<0.4045
Gill rakers	P<0.2386
Vertebrae	P<0.8141

B

Trawls	ED/SL	HL/SL
386 vs 340	P<0.001	P<0.001
386 vs 364	P<0.001	P>0.05
386 vs 259	P<0.001	P<0.01
340 vs 364	P>0.05	P<0.001
340 vs 259	P>0.05	P>0.05
364 vs 259	P>0.05	P>0.05

Table 5. Meristic characters (most frequent number and range, betwen brackets), of AC - photophores, number of rays of dorsal fin, number of rays of the pectoral fin, number of gill rakers and number of vertebrae) and morphometric characters expressed as (the percentages of standard length on the head length, eye orbit diameter and body depth of four species of *Maurolicus* and the species analysed in the present study.

	Number of Vertebrae	Number of Gill Rakers	Number of Photophores AC	Number of rays of the Pectoral Fin	HL/SL (%)	ED/SL (%)	BD/SL (%)
This study	34 (33)	27 (25-30)	26 (25-28)	17 (15-19)	27-33	8-11	20.5-24.5
M. stehmanni	33 (34)	28-29 (27-29)	25-26 (24-26)	17-19	27-29	8.5-10	23-25
M. muelleri	34 (33-35)	29-31 (28-32)	25-26 (23-27)	17-19	26-29	8-10	19-22
M. parvipinnis	34 (33-35)	27-28 (26-29)	24-25 (23-27)	16-18	28.5-32	9.5-12.5	22-25
M. weitzmani	33 (32-33)	22-24 (21-26)	23-24 (22-26)	17-19	29.5-33	9.5-11.5	22.5-25.5

The results indicate the influence of the Tropical Water in the upper layers, the winter temperatures of which varied from 18° C to 20° C, while in spring and autumn they reached 24° C.

On the shelf and the shelf break the variations were greater. The temperature profiles indicated the penetration of colder water over the shelfbreak along the area observed in transects 1, 2 and 3 (Figure 3). In autumn and spring this phenomenon was more vigorous than in winter, resulting in the presence of a seasonal thermocline over the Continental Shelf near Cabo Frio.

On the other hand, in winter and spring, at the southern limit of the area was observed the presence of cold water over the Continental Shelf, contrasting with the occurrence of warm water in autumn, without stratification of the water column at coastal stations (Transect 4, Figure 3). The hydrographic differences between the seasons may be explained by the position of the South Atlantic Subtropical Convergence Zone (STCZ). The presence of warm water (TW) in autumn suggests that at this time the STC lies north to 34° S, and the occurrence of cold water indicates that the STC is displaced northwards in winter.

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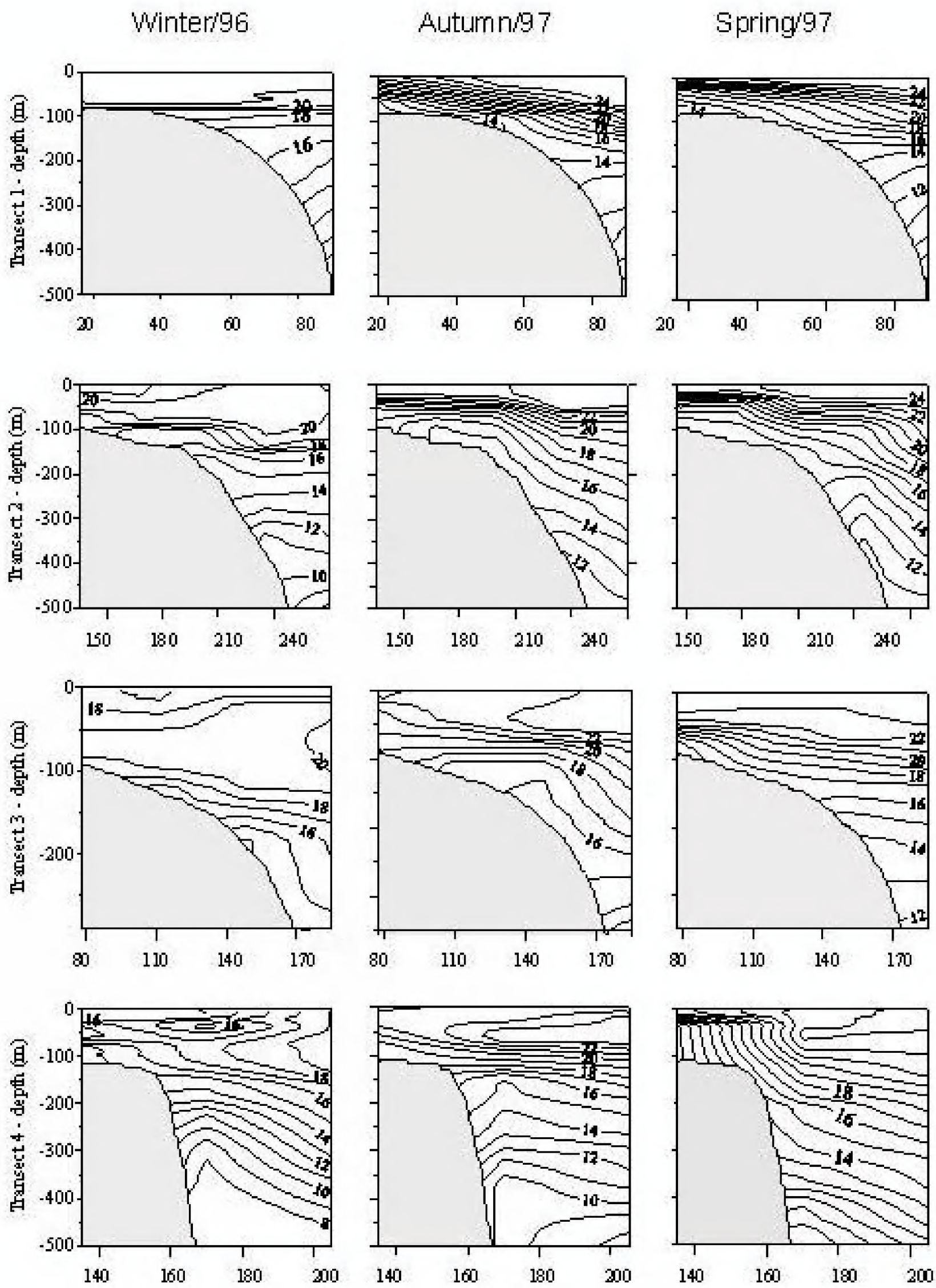

Figure 3. Vertical temperature (°C) profiles along the transects in the area during Winter 1996, Autumn 1997 and Spring 1997.

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Distribution of *Maurolicus stehmanni*

Figure 4 presents the areas in which *M. stehmanni* was detected during the hydroacoustic surveys, showing that most of the catches took place near the shelf break at 200 m isobaths, under the influence of the South Atlantic Central Water.

Before the present study Weiss et al. (1988) and Bonecker and Hubold (1990) in the southern region, and Ribeiro (1996) in the southeast one, analyzing the occurrence of eggs and larvae of *Maurolicus* (that they nominated *M. mulleri*) detected the importance of the species, while Madureira et al. (2005) presented important results about its high biomass value in the area. The shelf break is described by Lowe-McConnel (1999) as an interface between a neritic province characterized by high, but variable primary production (sensitive to climatic variations), and an oceanic province with low, but constant production. Recently, studies about mass balance of between 22° S and 34° S showed that the *M. stehmanni* biomass is used by 13 groups of species, including demersal and pelagic fish and squids of high economic value (Gasalla et al. 2007).

It was confirmed that the distribution of *M. stehmanni* during autumn extends further south than it does in spring and winter, and the southernmost limit of this species in Brazil fluctuates with the position of the STC, as suggested before by Bonecker and Hubold (1990). Moreover, Figueroa et al. (1988) did not report *Maurolicus* in the composition of the mesopelagic fish fauna during a survey conducted along the Southwestern Atlantic in an adjacent area of the present study (latitudes 36° to 54° S).

In Central and Northeast Brazilian waters, during an hydroacustic survey conducted between 22° S and 11° S, massive schools of *M stehmanni* were detected around 22° S (Madureira et al. 2004), while recent published studies carried out with mid-water trawls and bongo net confirmed the presence of adult *M. stehmanni* up to 16° S (Lima 2005; Braga et al. 2007) and larvae up to 12° S, respectively (Bonecker et al. 2006). However, during a hydroacustic survey conducted between 11° S and 3° S, Madureira et al. (2004) did not report the species in that area.

This study permit to say that the species inhabiting the South-Southeast Brazilian ZEE is *Maurolicus stehmanni*, being the south limit of its distribution the Subtropical Convergence position (around 34° S) and the north one 11° S.

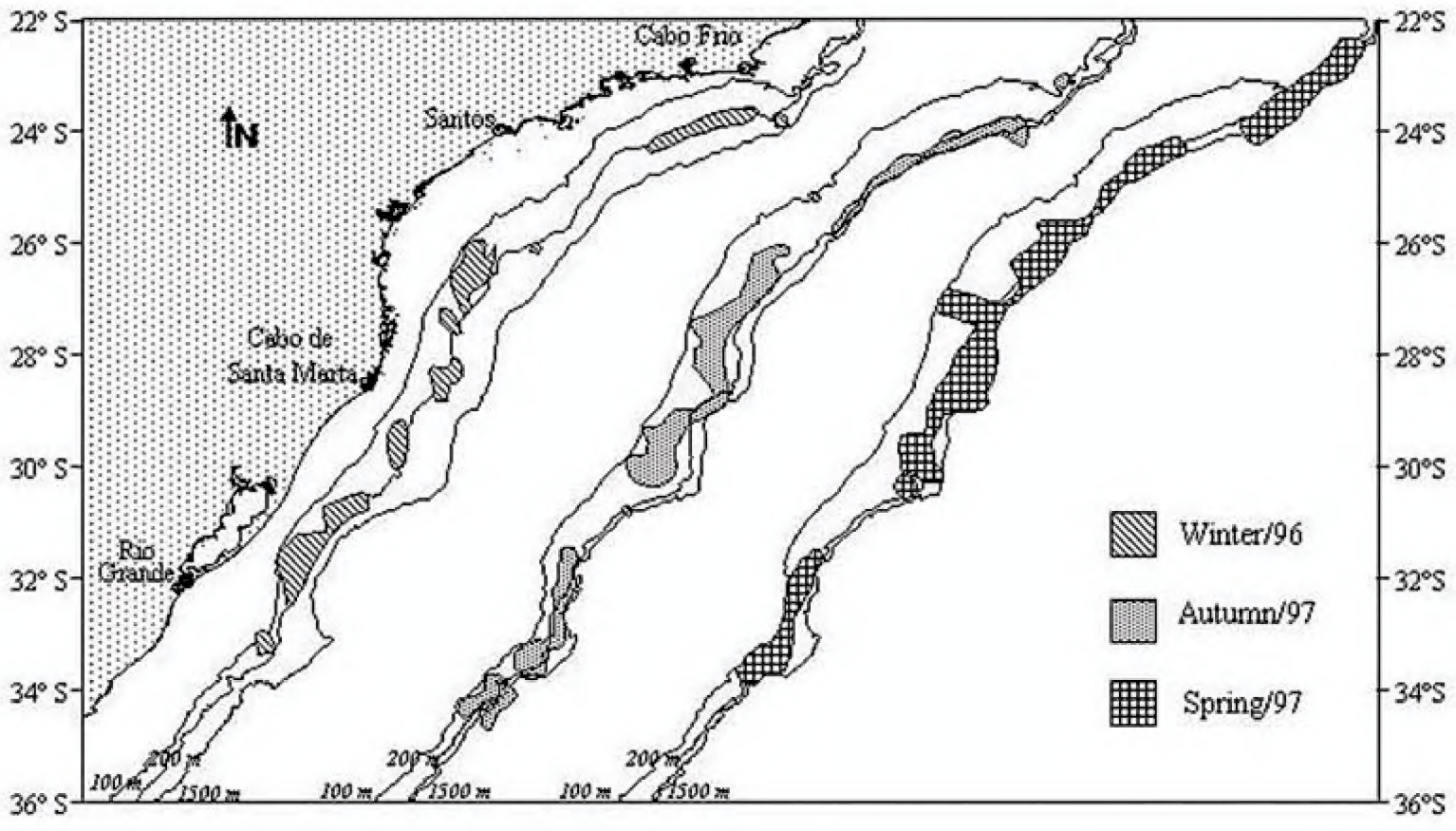

Figure 4. *Maurolicus stehmanni*: Distribution detected by hydroacoustic prospection in the southern and southeastern Brazilian EEZ during Winter 1996, Autumn 1997 and Spring 1997. Data from Hydroacoustic Laboratory, FURG, Brazil.

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Acknowledgements
The authors wish to thank Drs. Lauro Madureira and Ricardo Habiaga of FURG, for undertaking the hydroacoustic surveys, and Dr. José Lima de Figueiredo of the MZUSP, for discussions about the species identification. The help of the R.V. *Atlântico Sul* crew and the author's colleagues during the cruises and sampling was essential to the undertaking of this study, which was part of Almeida's MSc degree. The REVIZEE Program provided financial support.

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Received November 2006
Accepted October 2007
Published online November 2007